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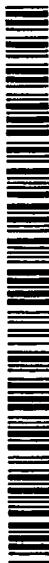


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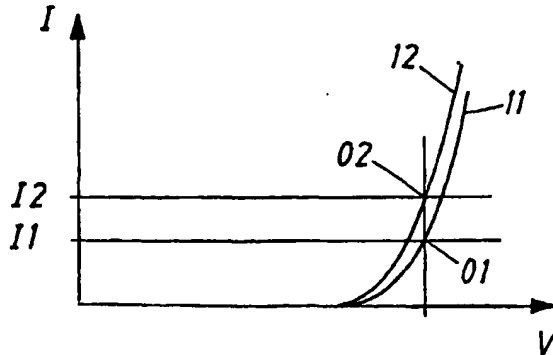
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(54) Title: A METHOD AND ARRANGEMENT FOR CONTROLLING A TUNEABLE LASER

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(57) Abstract: A method of controlling a tuneable laser that has been characterised with respect to one or more suitable laser operation points, where each of said operation points is determined by the manner in which the different laser sections (7-10) are controlled in order to operate the laser in a predetermined operation point. The invention is characterised by determining the voltage across the different laser sections (7-10) for different operation points when controlling said laser; and holding the voltage across the different laser sections (7-10) constant when the laser is in operation, such as to maintain a predetermined operation point.

**A METHOD AND ARRANGEMENT FOR CONTROLLING A TUNEABLE LASER**

The present invention relates to a method and to an arrangement for controlling a tuneable laser.

5

Tuneable semiconductor lasers include several different sections through which current is injected, these sections typically being three or four in number. The wavelength, power and mode purity of the lasers can be controlled by 10 adjusting the current in the various sections. Mode purity implies that the laser is at an operation point, i.e. at a distance from a combination of the drive currents where so-called mode jumps occur and where lasering is stable and side mode suppression is high.

15

Special requirements are required for different applications with respect to controlling wavelength. In the case of telecommunications applications, it is necessary that the laser is able to retain its wavelength to a very high degree 20 of accuracy over long periods of time, after having set the drive currents and the temperature. A typical accuracy is 0.1 nanometer and a typical time period is 20 years.

In order to be able to control the laser, it is necessary to 25 map the behaviour of the laser as a function of the various drive currents. This is necessary prior to using the laser after its manufacture.

Various methods of characterising tuneable lasers with 30 respect to optimising their operation points are described in Swedish Patent Specifications 9800143-1 and 9900536-5.

However, it is also necessary to determine degradation of a laser in operation in order to be able to compensate for degradation by changing the drive currents. A change in wavelength for a given operation point is one example of degradation.

Conventionally, tuneable lasers are controlled by adjusting the current injected into the various laser sections so as to retain a certain desired operation point.

10

One method of discovering laser degradation is to re-characterise the laser after a given time period and therewith compare earlier combinations with the current combinations last measured so as to determine the extent to 15 which the laser may have degraded. The current control of the various sections of the laser is then adjusted so as to obtain the desired operation point.

20 The present invention relates to a method and to an arrangement with which changes in the laser operation point with respect to transmitted wavelength, power and side mode suppression due to degradation is compensated so as to greatly reduce the influence of this degradation or to eliminate its influence entirely.

25

Accordingly, the present invention relates to a method of controlling a tuneable laser which has been characterised with respect to one or more suitable laser operation points, wherein each of the operation points is determined by the 30 extent to which the various sections of the laser are controlled to result in the laser operating in a predetermined operation point, and is characterised by

determining the laser control voltage across the different sections for different operation points; and holding the voltage across the various sections of the laser constant during operation of the laser over time and thereby maintain  
5 a predetermined operation point.

The invention also relates to an arrangement that has the characteristic features set forth in Claim 4.

10 The invention will now be described in more detail with reference to exemplifying embodiments thereof and also with reference to the accompanying drawings, in which

- Figure 1 is a partially cut-away perspective view of a DBR laser;

15 - Figure 2 is a sectional view of a tuneable Grating Coupled Sampled Reflector (GCSR) laser;

- Figure 3 is a sectional view of a Sampled Grating DBR laser;

20 - Figure 4 shows principle curves in a diagram in which current injected in one tuning section is plotted against the voltage across said section; and

- Figure 5 is a block diagram illustrating schematically an arrangement used in accordance with the invention.

25 Figure 1 illustrates a DBR laser which includes three sections, namely a Bragg reflector 1, a phase section 2 and a gain section 3. Each section is controlled by injecting current thereinto through respective electrical conductors 4, 5, 6.

30

Figure 2 is a section view of a tuneable Grating Coupled Sampling Reflector (GCSR) laser. Such a laser has four

sections, namely a Bragg reflector 7, a phase section 8, a coupler 9 and a gain section 10. Each of the sections is controlled by injecting current thereinto.

5 Figure 3 is a section view of a Sampled Grating DBR laser, which also has four sections referenced 11, 12, 13, 14 respectively. The sections 11 and 14 are Bragg reflectors, whereas section 13 is the phase section and section 12 the gain section.

10

The aforesaid three types of lasers are common. However, other types of lasers exist.

15 Although the invention is described below mainly with reference to a GCSR laser according to Figure 2, it will be understood that the invention is not restricted to any particular kind of tuneable semiconductor lasers. For instance, the invention can be applied in a corresponding manner with tuneable lasers other than those shown in the 20 Figures by way of example.

25 The wavelength emitted by a tuneable laser is determined by the amount of current that is injected into the different laser sections. Wavelength is determined by the number of free charge carriers to which the injected current gives rise. Degradation in the relationship between wavelength and current can occur in time and therewith destroy the wavelength accuracy of the laser.

30 This degradation occurs primarily in the relationship between current and refractive index, by virtue of a change in the

ratio between the injected current and the number of charge carriers.

5 The ratio between the number or charge carriers and refractive index, and therewith wavelength, however, can be considered to be constant.

10 Thus, the invention relates to a method of controlling a tuneable laser which has earlier been characterised with respect to one or more suitable laser operation points. The operation points are determined by the current to be injected into the different laser sections, or by the voltage that shall prevail across respective sections, in order for the laser to operate in a predetermined operation point.

15

According to the invention, the voltage across the different laser sections for different laser operation points is determined when characterising the laser. In operation, the voltage across the different laser sections is held constant 20 over time so as to maintain a predetermined operation point.

25 The laser can be characterised in accordance with the aforesaid patent specifications, such as to identify a large number of operation points, and thereafter select a given operation point. However, the invention can also be applied when the laser is controlled digitally or analogously to obtain a given operation point. The invention is therefore not dependent on how a given operation point is obtained.

30 In fact, the relationship between current that passes through a section and the applied voltage across said section is not

linear and, furthermore, is changed with degradation of the laser. This applies to all laser sections.

Figure 4 is a diagram in which the current  $I$  through one section has been plotted against the voltage across said section. The curve 11 shows this relationship when characterising the laser prior to its degradation. The point 01 shows a selected operation point. The position of the curve 11 moves to the position of the curve 12 when degradation occurs. Thus, the operation point can be caused to move to the point 02, by holding the voltage constant. The result of holding the voltage constant is thus to increase the current through the section from  $I_1$  to  $I_2$ .

15 This is preferably effected by causing the voltage unit 13 to supply voltage to each of the laser sections with predetermined constant voltages across respective sections.

20 This results in automatic correction of the current through respective sections and in a constant quantity of free charge carriers, even when the ratio between injected current and the number of charge carriers changes. This applies to all sections of the laser.

25 Consequently, the wavelength of the emitted light will be held constant over said time period even should the laser degrade. Although an exact wavelength may not be maintained over the full time period, the influence of degradation will at least be greatly reduced.

As distinct to conventional processes, it is not necessary to measure the current nor to correct the current to a certain predetermined value.

- 5 In actual fact, it is unnecessary to know the extent to which the laser has degraded in order to maintain a given operation point, and therewith wavelength, when practicing the present invention.
- 10 The present invention thus solves the problem disclosed in the introduction.

Figure 5 is a block diagram of an arrangement used in accordance with the invention.

- 15 In operation, the voltage unit 13 functions to keep the voltage across the different laser sections 7-10 constant over a time period for maintaining a predetermined operation point. The various voltages required in this respect are determined when characterising or controlling the laser as relevant voltages across the various laser sections for different operation points.
- 20

- When characterising the laser, for instance in accordance with the aforesaid patent specifications, the voltage across the various laser sections can be measured in respect of the different operation points.

- 30 The arrangement includes a microprocessor 14 or some corresponding device for controlling four different voltage generators 16-19 via a D/A converter 15. Each of the voltage generators 16-19 controls one of the laser sections 7-10. The

microprocessor is connected to a storage in which the different operation points are stored in the form of that voltage which shall prevail across respective laser sections.

5 According to one preferred embodiment, the arrangement includes a circuit 20 which is adapted to measure the voltage across respective sections 7-10. The circuit 20 is designed to adjust the voltage unit 13 so that it will maintain a predetermined voltage for each laser section. This is  
10 effected in response to a signal delivered to the microprocessor 14 from the circuit 20 and representing respective measured voltages.

The microprocessor and the D/A converter can be replaced with  
15 a fully analog circuit. In such case, the circuit 20 may also be included in a similar analog circuit.

Although the invention has been described above with reference to an exemplifying embodiment thereof, it will be  
20 understood that the invention can be applied correspondingly to types of tuneable lasers other than a GCSR laser. The voltage generators may also be given any suitable design, as can also the circuit 20.

25 The present invention shall not therefore be considered limited to the aforescribed embodiment, since variations can be made within the scope of the following Claims.

## CLAIMS

1. A method of controlling a tuneable laser that has been characterised with respect to one or more suitable laser operation points, where each of said operation points is determined by the manner in which the different laser sections (7-10) are controlled in order to operate the laser in a predetermined operation point, **characterised by** determining the voltage across the different laser sections (7-10) for different operation points when controlling said laser; and holding the voltage across the different laser sections (7-10) constant when the laser is in operation, such as to maintain a predetermined operation point.
- 15 2. A method according to Claim 1, **characterised by** applying predetermined constant voltages across respective laser sections (7-10) with the aid of a voltage supply unit (13).
- 20 3. A method according to Claim 1 or 2, **characterised by** measuring the voltage across respective sections (7-10), and adjusting the voltage supply unit (13) so as to maintain said predetermined voltage across each section (7-10).
- 25 4. An arrangement for controlling a tuneable laser that has been characterised with respect to suitable laser operation points, where said operation points are determined by the current to be injected into the different laser sections (7-10) in order for the laser to operate in a predetermined operation point, **characterised by** a voltage unit (13) which during operation of the laser functions to hold the voltage across the different laser sections (7-10) constant over time in accordance with the voltage that was measured across the

different laser sections (7-10) in respect of said different operation points measured when characterising the laser, such as to maintain a predetermined operation point.

5. An arrangement according to Claim 4, **characterised** by a circuit (20) that functions to measure the voltage across respective sections (7-10), wherein the circuit (20) is adapted to adjust the voltage unit (13) to maintain said predetermined voltage across each section (7-10).

Fig. 1

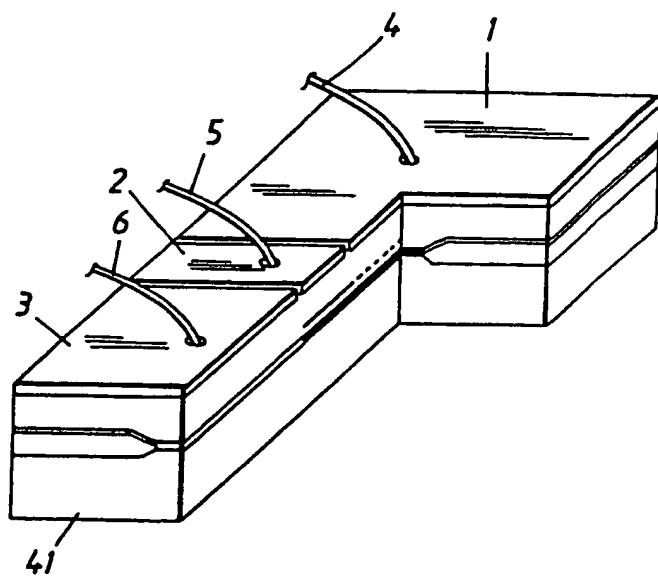


Fig. 2

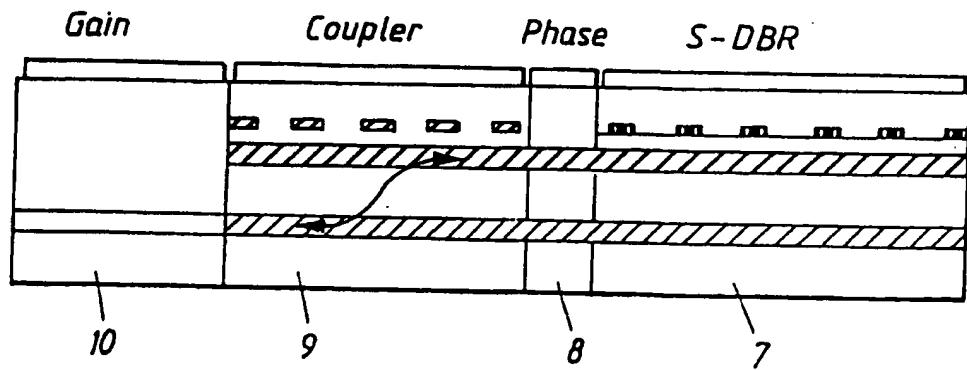


FIG. 3

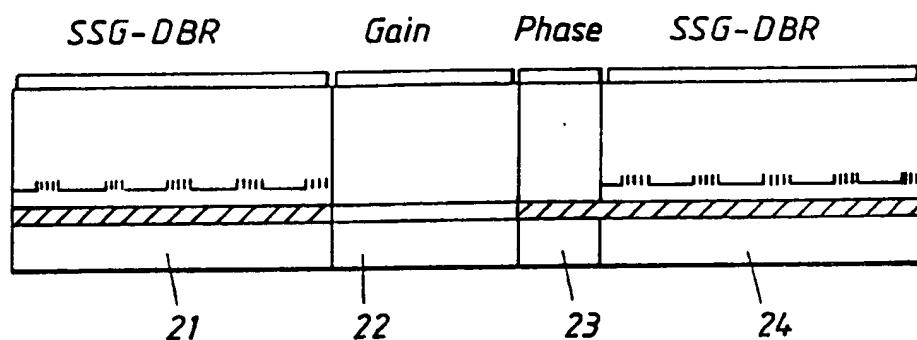


FIG. 5

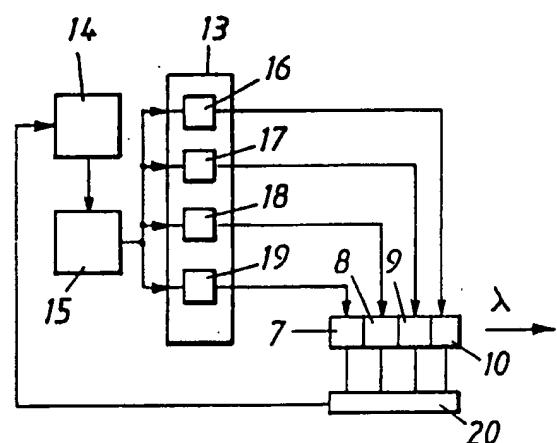
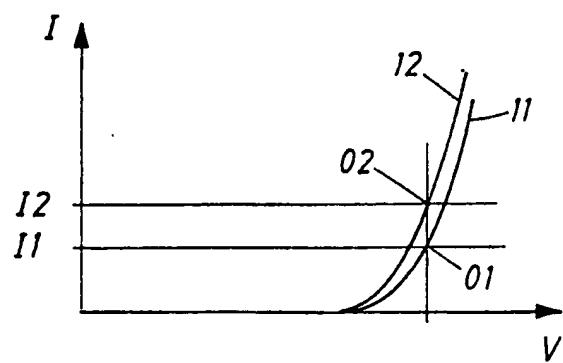


FIG. 4



## INTERNATIONAL SEARCH REPORT

International application No. PCT/SE 00/01320
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## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01S 5/0625, H01S 5/068

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	US 6064681 A (DAVID ALAN ACKERMAN), 16 May 2000 (16.05.00), see whole document  -- -----	1-5

<input type="checkbox"/> Further documents are listed in the continuation of Box C.	<input checked="" type="checkbox"/> See patent family annex.
<p>* Special categories of cited documents:            "A" document defining the general state of the art which is not considered to be of particular relevance            "E" earlier document but published on or after the international filing date            "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)            "O" document referring to an oral disclosure, use, exhibition or other means            "P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention            "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone            "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art            "&amp;" document member of the same patent family</p>

Date of the actual completion of the international search  <u>25 October 2000</u>	Date of mailing of the international search report  <u>02-11-2000</u>
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer  <u>Fredrik Wahlin/MN</u> Telephone No. + 46 8 782 25 00

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

03/10/00

International application No.

PCT/SE 00/01320

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6064681 A	16/05/00	NONE	-----